CERES FLASHFlux Status:

Near-Real Time Surface Radiative Fluxes and Meteorology for Research and Applications

Paul Stackhouse, David P. Kratz, Takmeng Wong, (NASA LaRC)
Shashi Gupta, Anne Edwards and Anne Wilber (SSAI)
Seiji Kato, David Doelling and Erika Geier (NASA LaRC)
And the Atmospheric Science Data Center Team (SSAI)

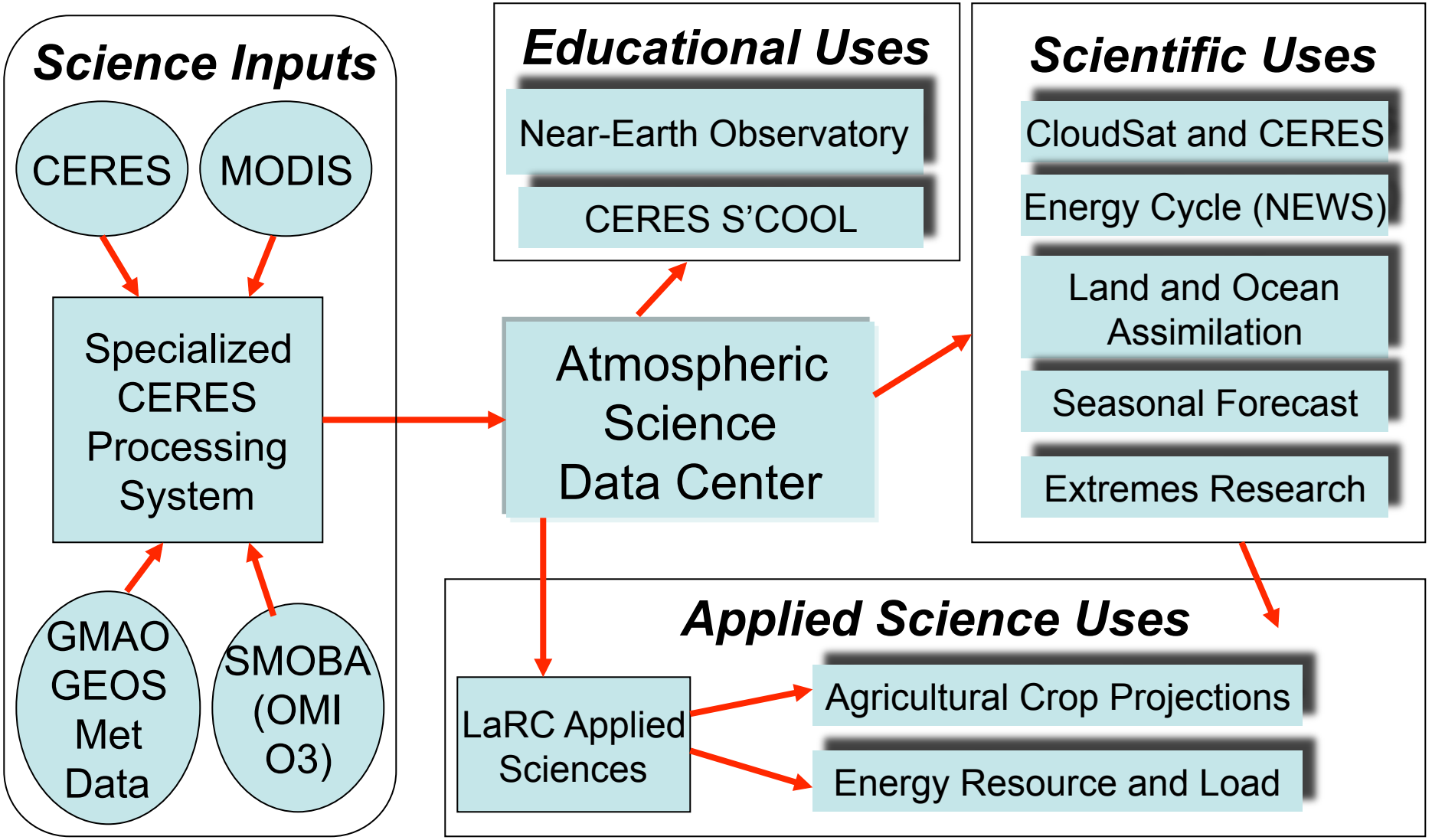
FLASHFlux Talk Overview

- ***Objectives***
- ***Processing and Data Products***
- ***Data Product Validation***
  - Surface measurements
  - CloudSat observations
- ***Scientific and Applied Science Uses***
  - Example: TOA Variability
- ***Future Plans***
- ***Summary and Conclusions***

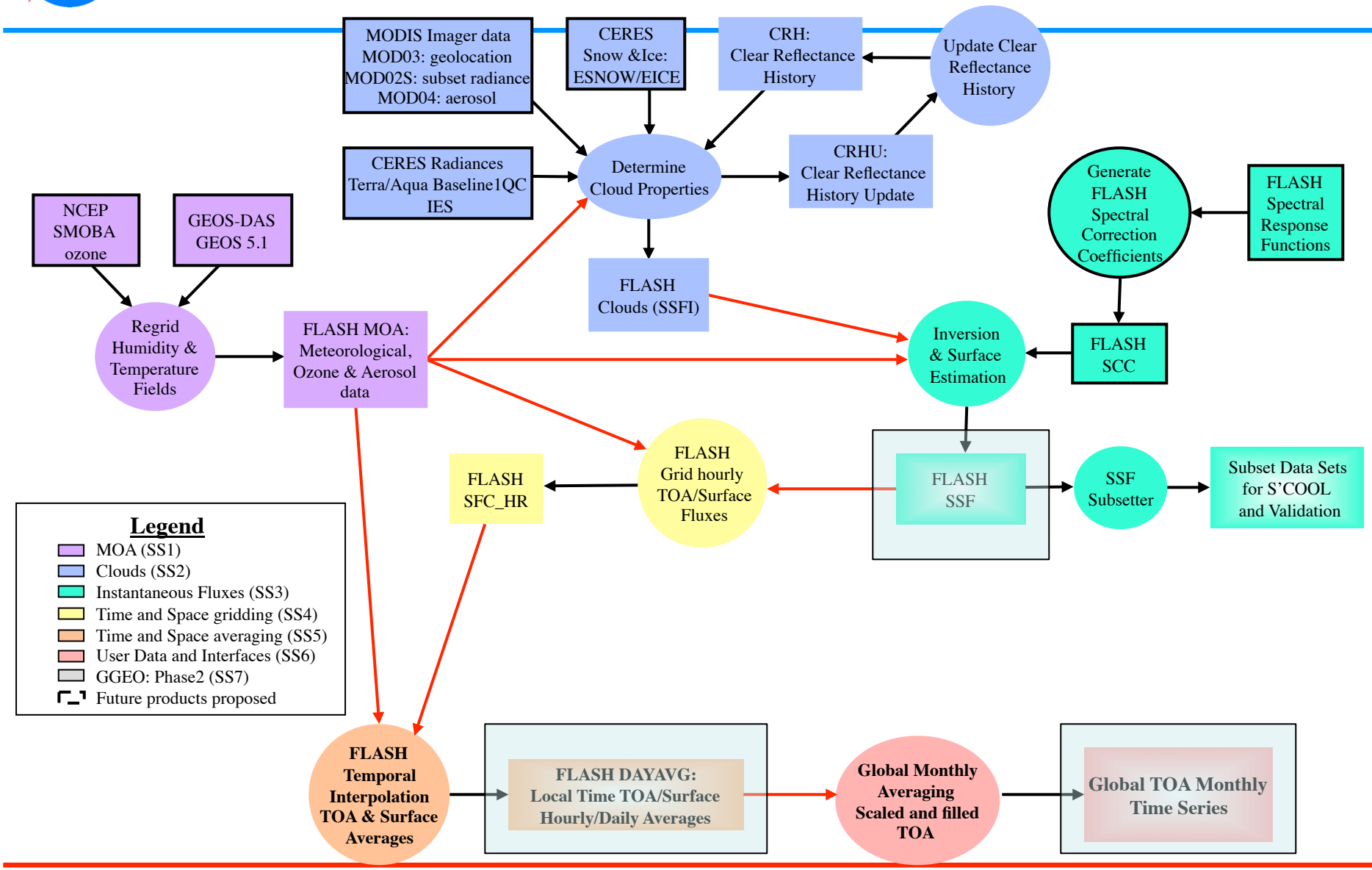
FLASHFlux Overview

- ***Fast Longwave And Shortwave Radiative Fluxes from CERES and MODIS => FLASHFLUX***
- ***FLASHFlux Objectives***
  - Compute radiative fluxes from CERES and MODIS observations from both Terra and Aqua within one week of measurement (currently available within 5 days)
  - Global gridded and time averaged radiative flux and meteorological data sets using both Terra and Aqua when available (currently available within 7 days)
  - Conduct scientific investigations and provide for scientific and applied science uses
  - Demonstrate processing system adaptable to NPP and beyond pushing data products to research and applications uses

FLASHFLUX: Schematic Mapping to Realized and Potential Uses



FLASHFlux Data Flow

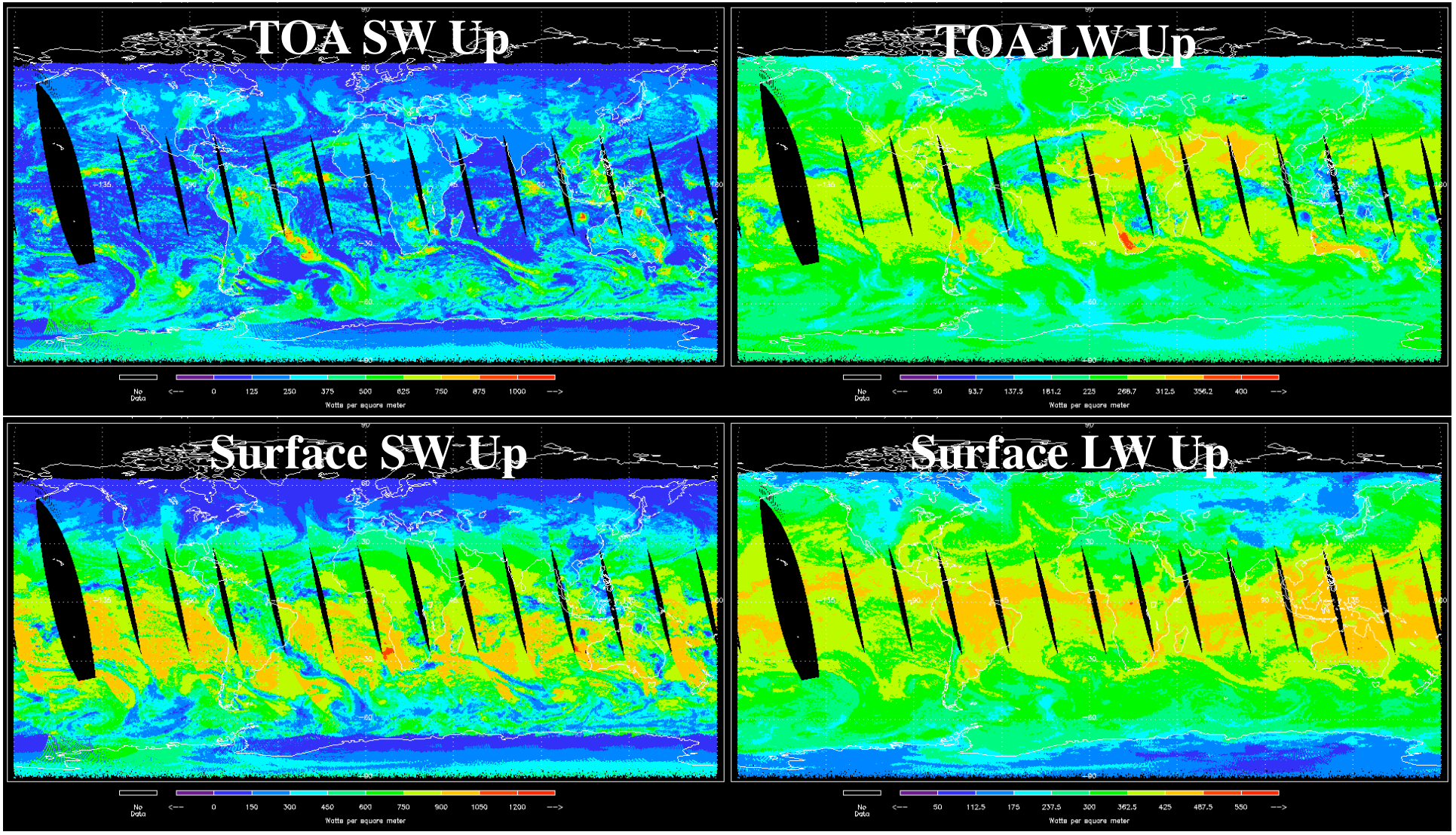


FLASHFlux SSF Data Products

CERES-like Single Scanner Footprint (SSF) (Terra and Aqua overpasses; 30 km nadir; Processed through near 10/30/2009)

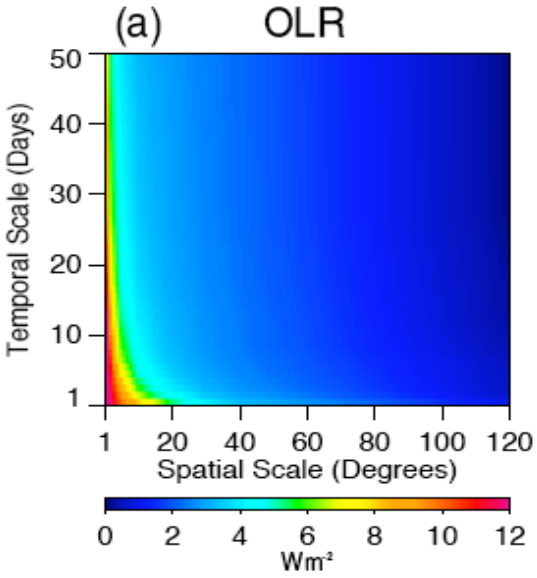
Single Scanner Footprint TOA/Surface Fluxes and Clouds (SSF): One hour of instantaneous FLASHFlux data for a single scanner instrument.				
Select Parameters: Cloud Properties, TOA Fluxes, Surface (Radiative) Fluxes, Unfiltered Radiances, Filtered Radiances, OLR, Surface Types.				
Spacecraft	**Data Set Name** (Select name to order)	**Temporal Coverage (Hourly)**	**Documentation**	**Sample Software**
Aqua	FLASH_SSF_Aqua-FM3-MODIS_Version2F	Jun 23, 2009 - current	Data Quality Summary FLASH SSF Version2 | CERES SSF Data Products Catalog R4V1 (PDF)	Readme R4-555 | Read Package (C).
	FLASH_SSF_Aqua-FM3-MODIS_Version2E	Sep 1, 2008 - Jul 1, 2009		
	FLASH_SSF_Aqua-FM3-MODIS_Version2D	Nov 30, 2007 - Sep 30, 2008		
	FLASH_SSF_Aqua-FM3-MODIS_Version2C	Sep 30, 2007 - Dec 31, 2007		
	FLASH_SSF_Aqua-FM3-MODIS_Version2B	Mar 31, 2007 - Oct 8, 2007		
Terra	FLASH_SSF_Terra-FM1-MODIS_Version2F	Jun 23, 2009 - Current	Data Quality Summary FLASH SSF Version2 | CERES SSF Data Products Catalog R4V1 (PDF)	
	FLASH_SSF_Terra-FM1-MODIS_Version2E	Sep 1, 2008 - Jul 1, 2009		
	FLASH_SSF_Terra-FM1-MODIS_Version2D	Nov 30, 2007 - Sep 30, 2008		
	FLASH_SSF_Terra-FM1-MODIS_Version2C	Sep 30, 2007 - Dec 31, 2007		
	FLASH_SSF_Terra-FM1-MODIS_Version2B	Mar 31, 2007 - Oct 8, 2007		

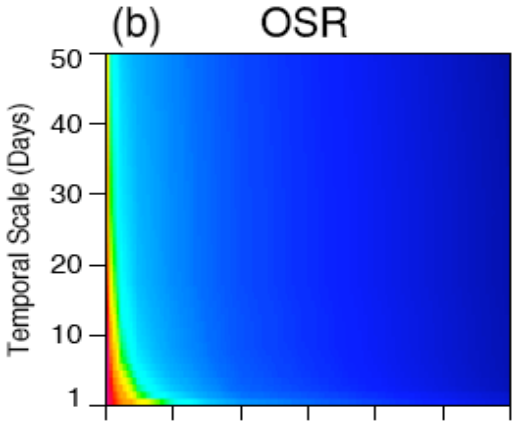
Overpass Footprint Resolution Products (Daytime Composite, Dec 27, 2008).



FLASHFlux SSF Validation

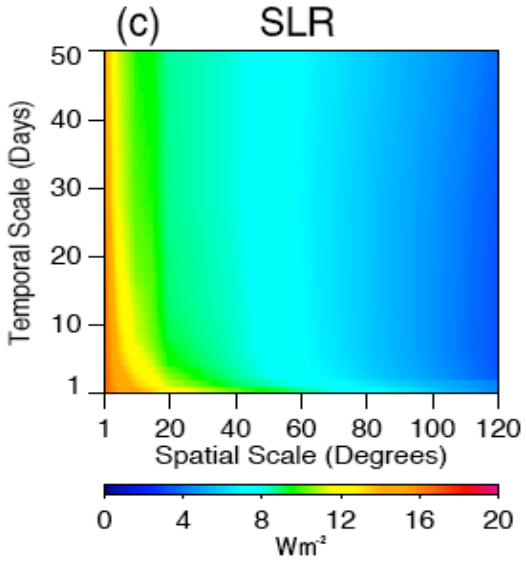
CloudSat Fluxes vs. FLASHFlux (L'Ecuyer et al., 2008)

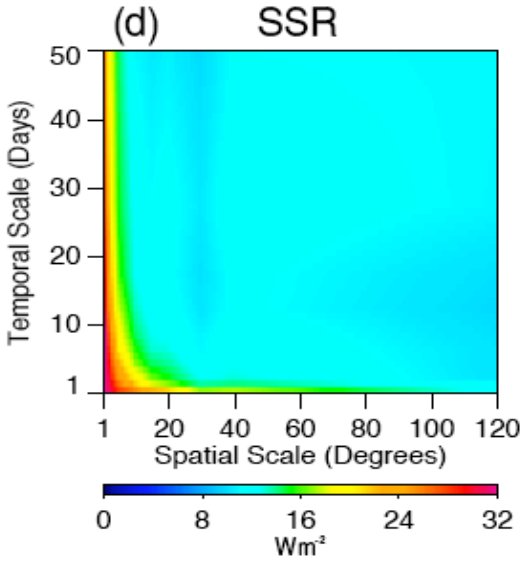




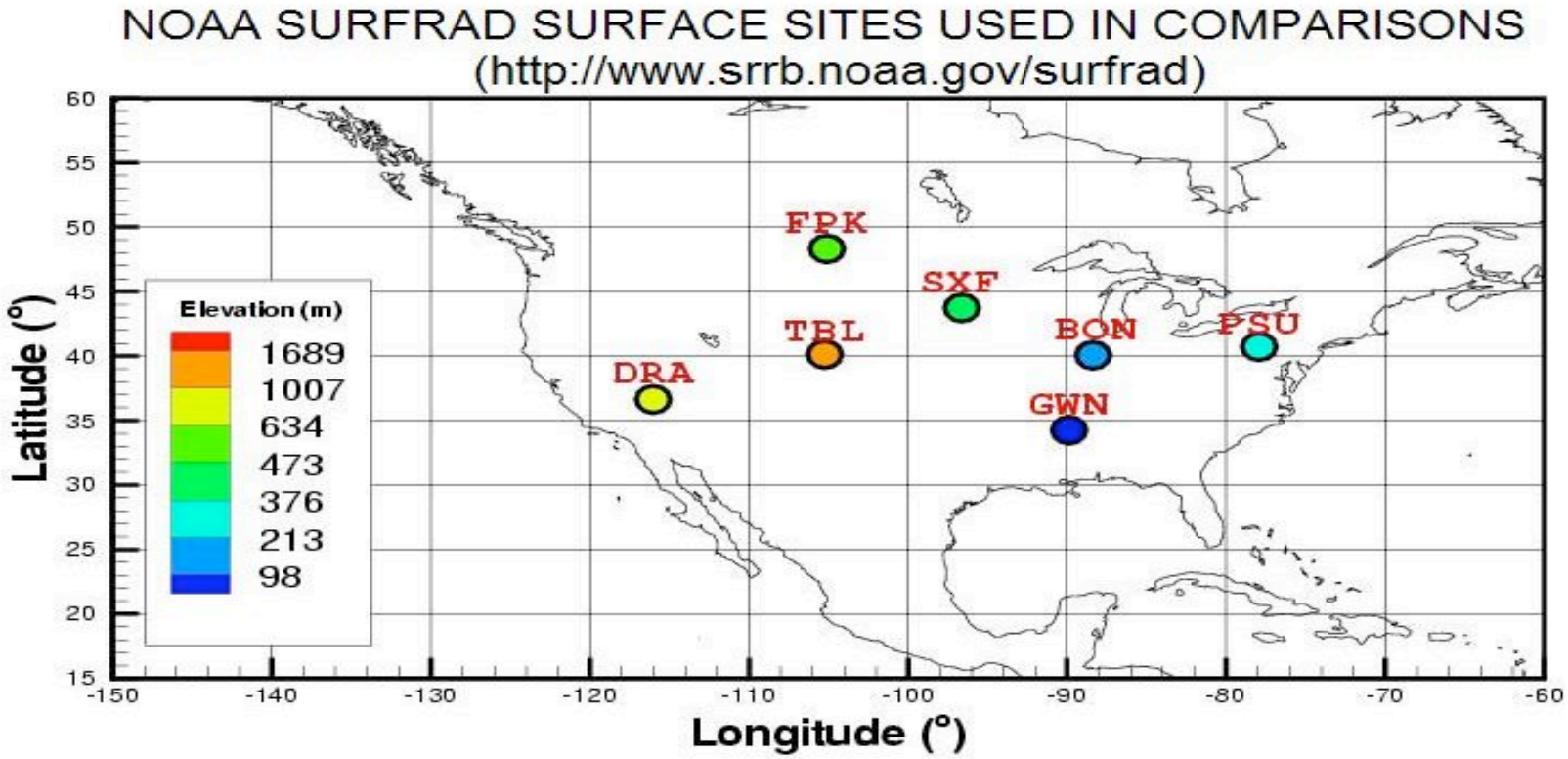
Outgoing LW (a) and SW (b) RMS Flux differences

Surface LW (c) and SW (d) RMS Fluxes differences





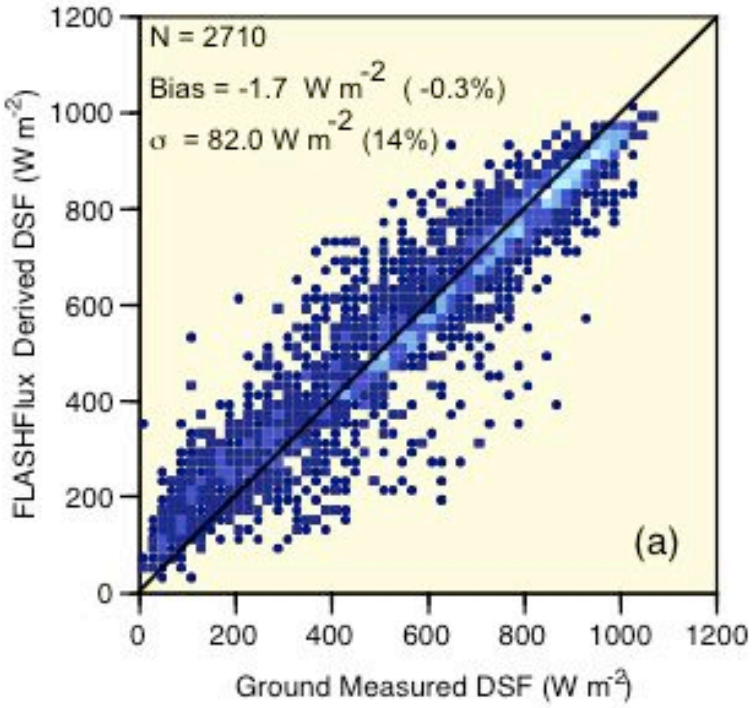
FLASHFlux: Validation Sites

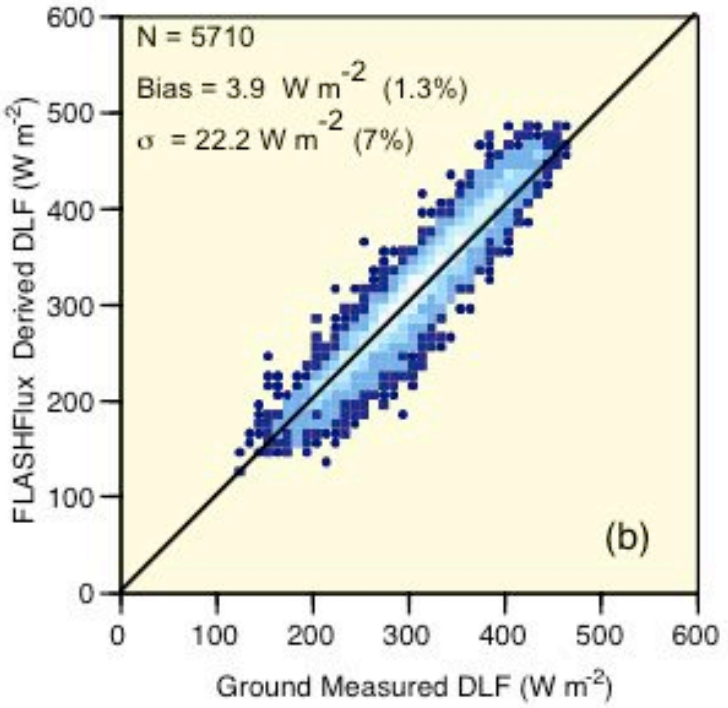


FPX – Fort Peck, MT; SXF – Sioux Falls, SD; BON – Bondville, IL;
DRA – Desert Rock, NV; TBL – Table Mountain, CO;
PSU – Penn State, PA; GWN – Goodwin Creek, MS

FLASHFlux SSF Validation

Instantaneous validation against SURFRAD measurements from April 2007 - March 2008





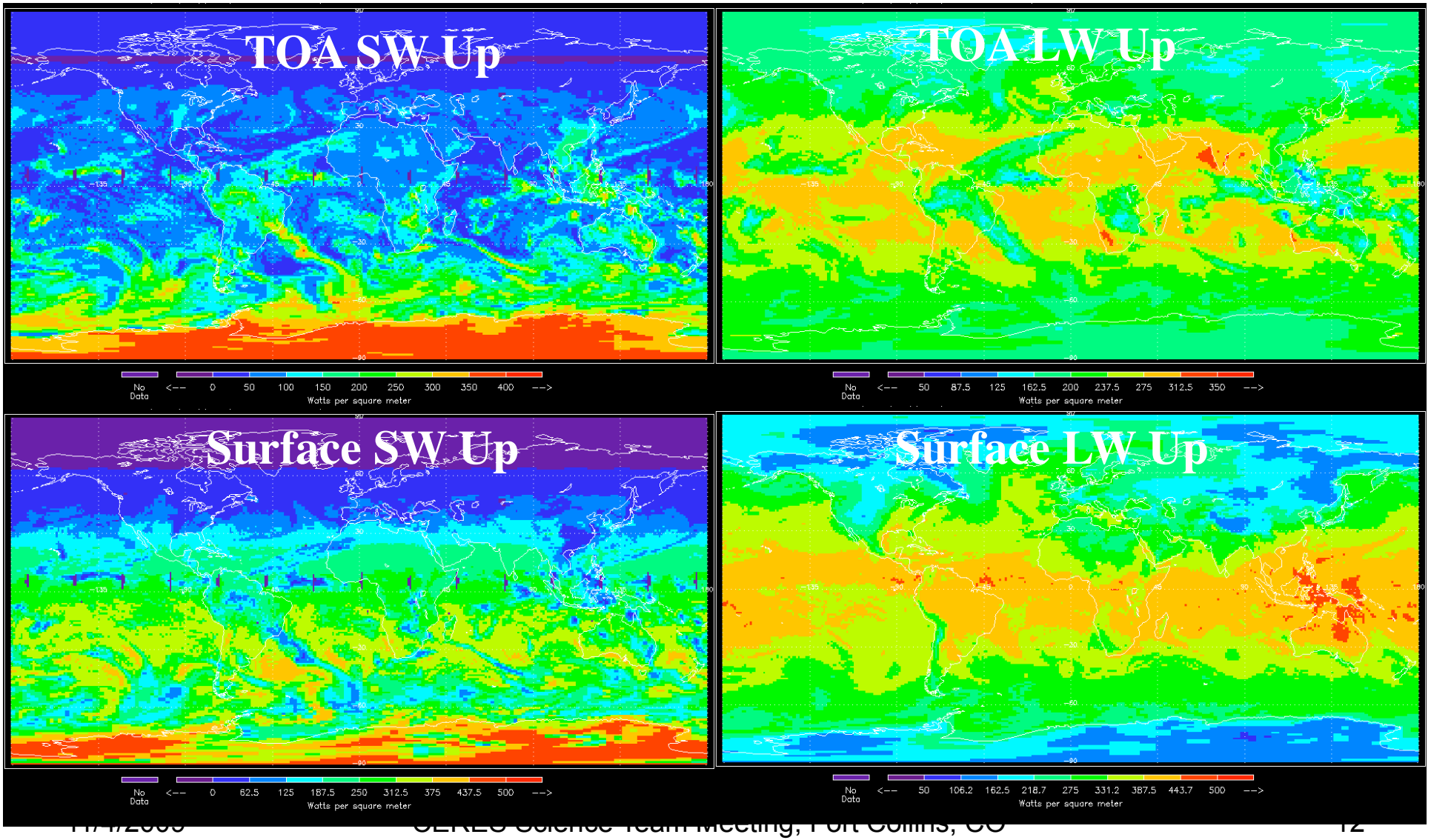
FLASHFlux Data Products

FLASHFlux Gridded and Temporally Averaged Data Products (Terra+Aqua; Hourly/Daily; 1ºx1º resolution; Processed through about 10/28/2009)

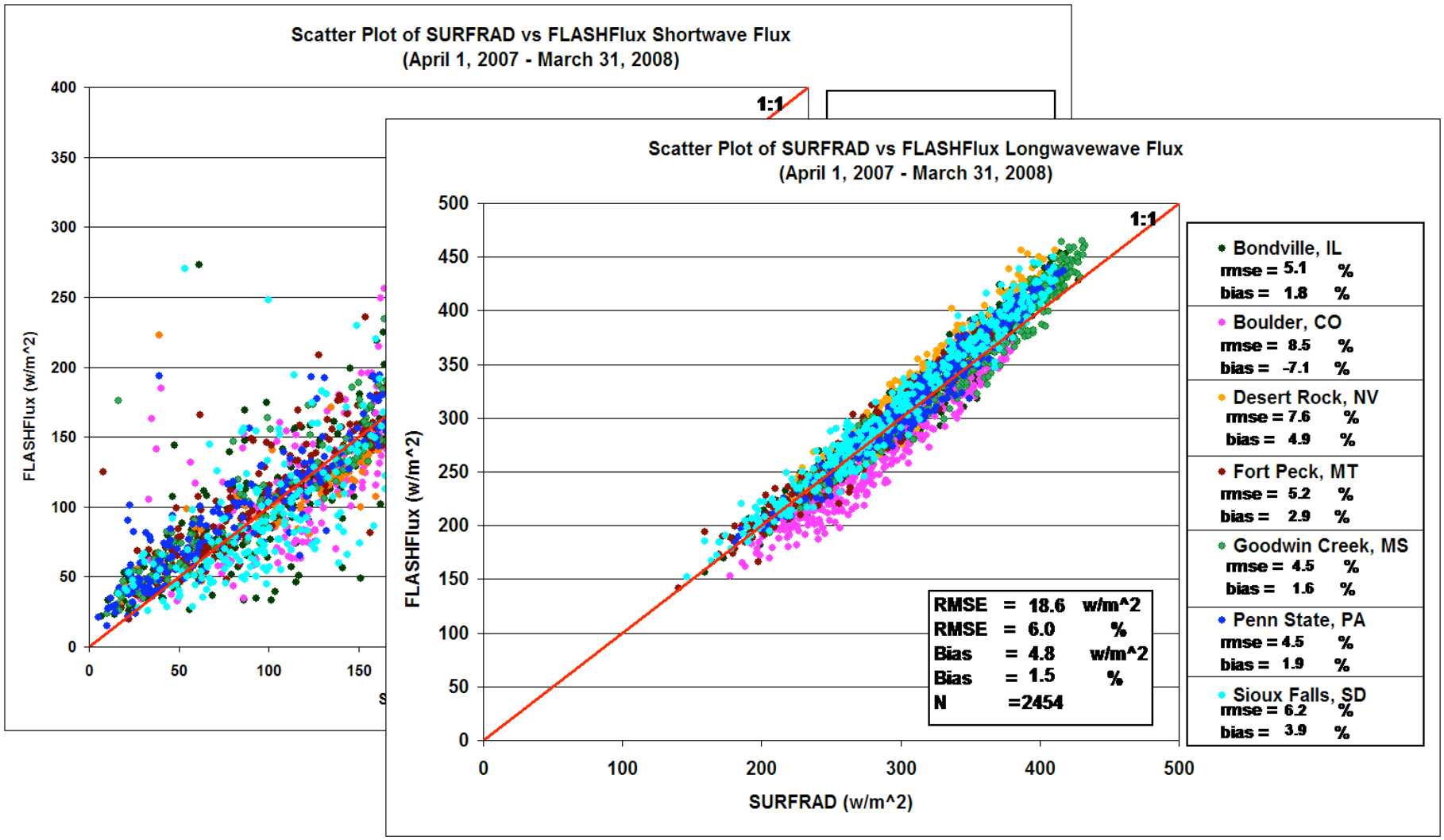
Daily Gridded Single Satellite TOA and Surfaces/Clouds data in HDF (TISA): One day of averaged FLASHFlux data for available scanner instruments.				
Select Parameters: Cloud Properties, TOA Fluxes, Surface (Radiative) Fluxes, OLR, Surface Types. (Complete Parameter List) **Note**: Beta data products are NOT regarded as publishable and will not be maintained in the archives.				
Spacecraft	**Data Set Name** (Select name to order)	**Temporal Coverage (Daily)**	**Documentation**	**Sample Software**
Terra + Aqua	FLASH_TISA_Terra+Aqua_Version2F	Jun 29, 2009 - current	Data Quality Summary FLASH TISA Version2	Readme R1V1 | Read Package (C).
	FLASH_TISA_Terra+Aqua_Version2E	Sep 1, 2008 - Jun 30, 2009		
	FLASH_TISA_Terra+Aqua_Version2D	Dec 1, 2007 - Sep 30, 2008		
	FLASH_TISA_Terra+Aqua_Beta6	Oct 1, 2007 - Dec 2007	not available	
	FLASH_TISA_Terra+Aqua_Beta5	Apr 1, 2007 - Oct 6, 2007		
	FLASH_TISA_Terra+Aqua_Beta4	Jan 1, 2007 - Apr 29, 2007		
	FLASH_TISA_Terra+Aqua_Beta3	Jul 1, 2006 - Apr 30, 2007		

FLASHFlux Gridded and Temporally Averaged Data Products (Dec. 28,2008)

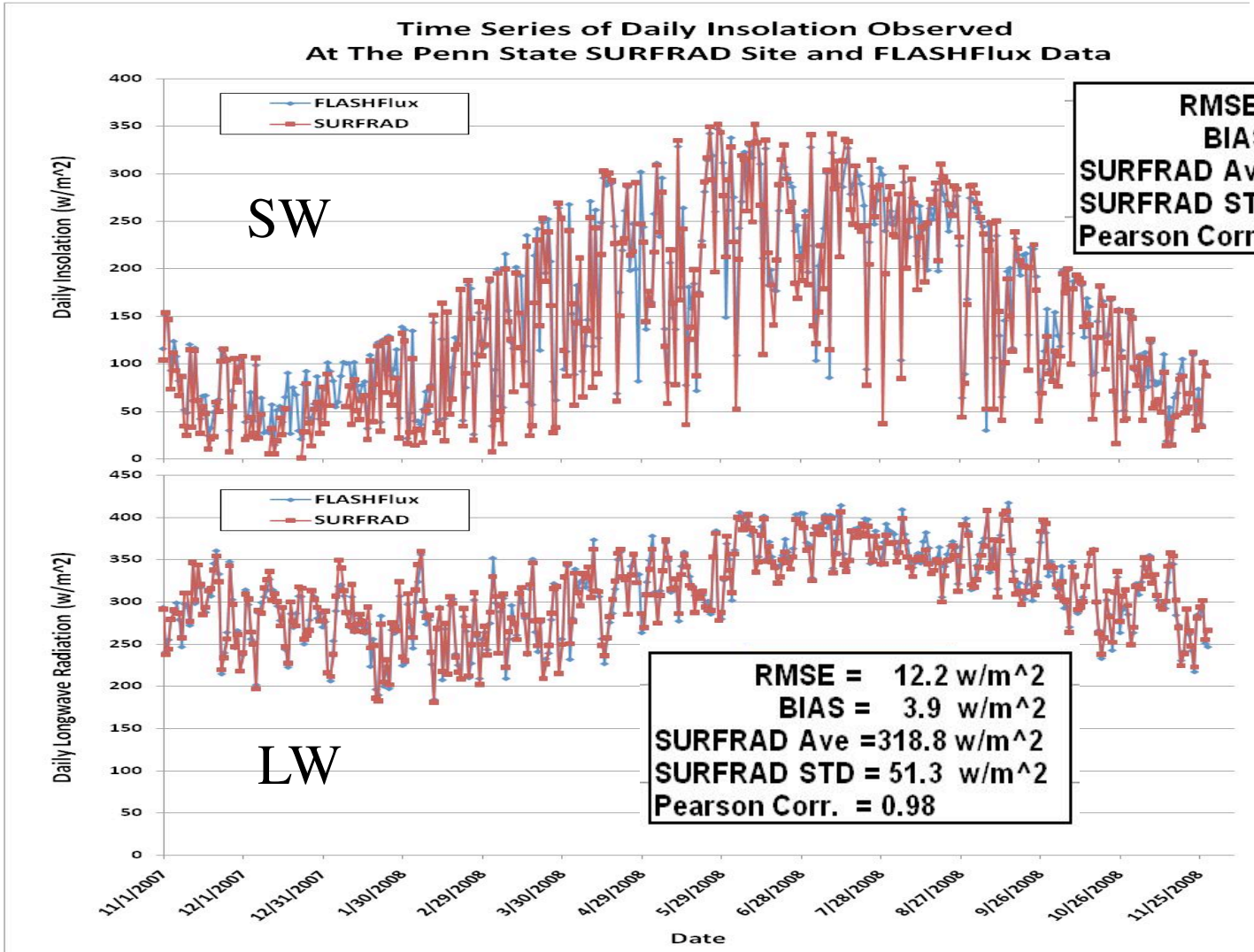
(Terra+Aqua; Daily; 1ºx1º resolution)



Time & Space Averaged Validation

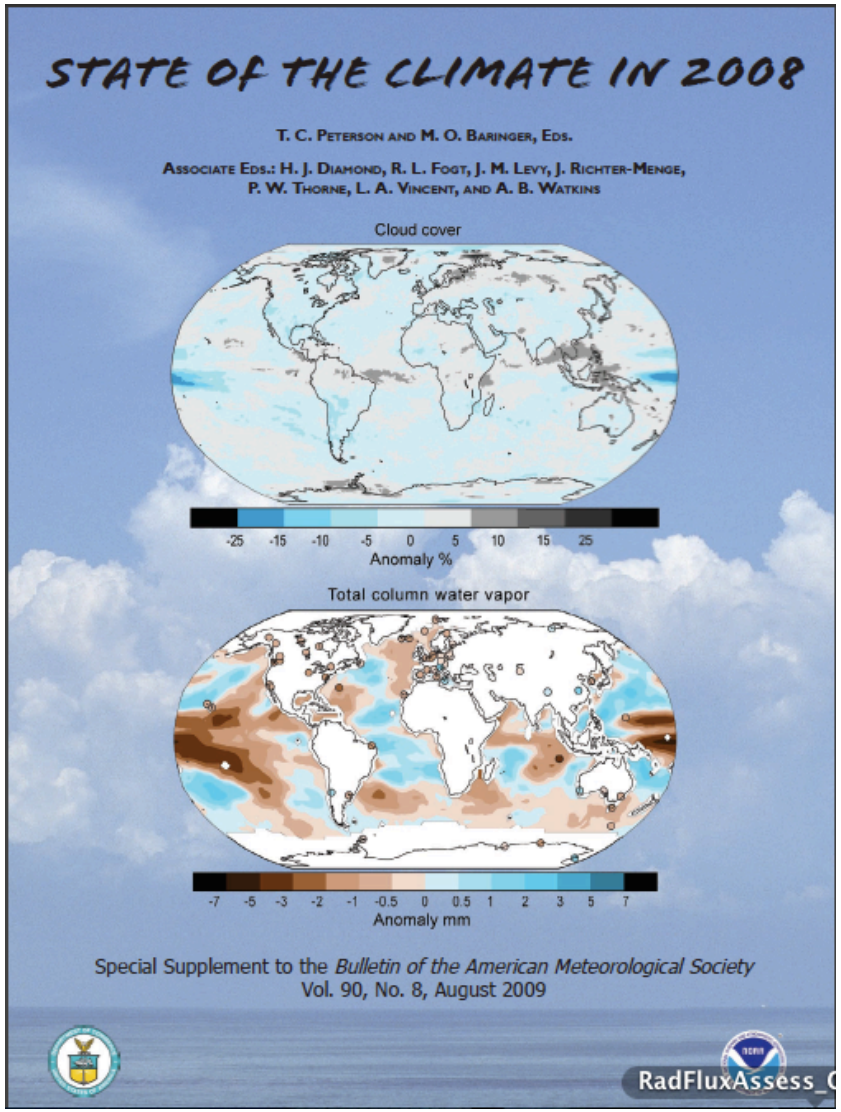


Daily Averaged FLASHFLUX Time Series Comparisons for SW and LW



Flux Time Series Compared to the Penn State SURFRad site with statistics.

Global Averaged TOA Flux Estimates



- *We were invited by NOAA/NCDC last November to participate in their special annual BAMS report on the "State of the Climate in 2008".*
- *Issue appeared in Aug. 2009, providing estimates of changes in year to year Global Earth Radiation Budget for the first time.*
- *These data have now been extended and used longer overlap with CERES ERBE-like products.*

Data Merging Process

CERES Terra EBAF Edition1A 3/2000 to 10/2005

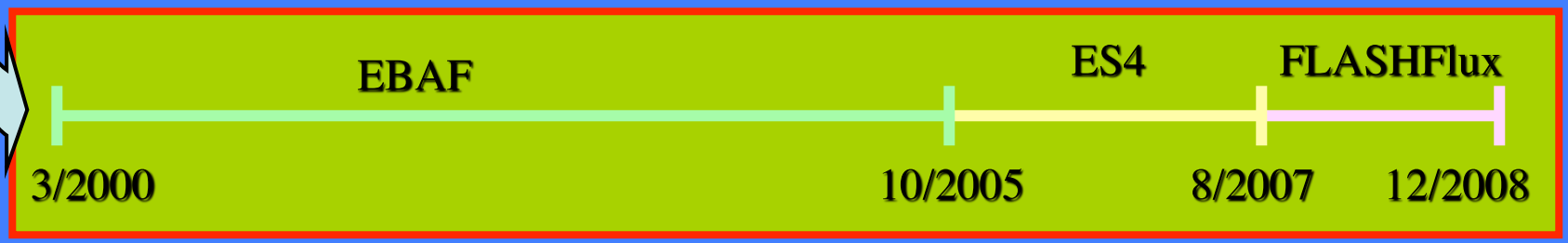
CERES Terra ERBE-like ES4 Edition2_Rev1 1/2003 to 8/2007

FLASHFlux Terra+Aqua 7/2006 to 12/2008

(Overlap: 1/2003 to 10/2005)

(Overlap: 7/2006 to 8/2007)

- Use overlap periods to remove mean difference between datasets
- Anchor the entire time series to the absolute values of the EBAF



Data Merging Process

CERES Terra EBAF Edition1A 3/2000 to 10/2005

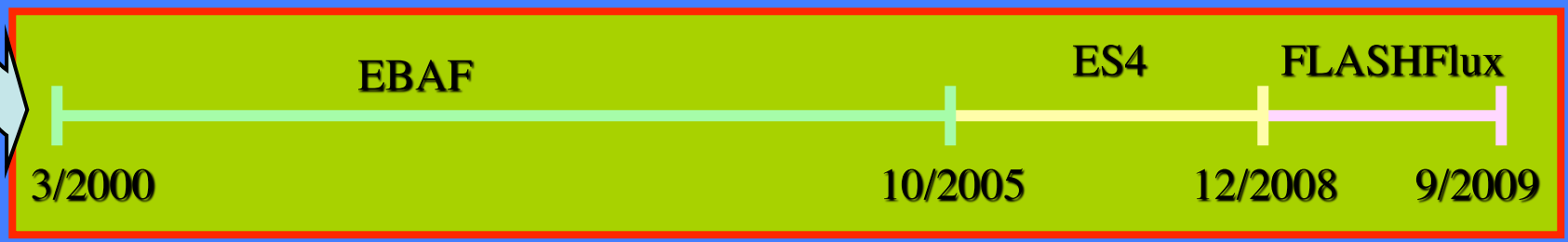
CERES Terra ERBE-like ES4 Edition2_Rev1 1/2003 to 12/2008

FLASHFlux Terra+Aqua 7/2006 to 12/2008

(Overlap: 1/2003 to 10/2005)

(Overlap: 7/2006 to 12/2008)

- Use overlap periods to remove mean difference between datasets
- Anchor the entire time series to the absolute values of the EBAF



Global Mean Differences and Adjustment Factors (Original)

ERBE-like minus EBAF (Wm^{-2})

	Mean	Std. Dev.
LW	-0.62	± 0.1
SW	-1.42	± 0.4
Net	3.46	± 0.5

FLASHFlux minus ERBE-like (Wm^{-2})

	Mean	Std. Dev.
LW	-1.36	± 0.1
SW	-2.02	± 0.5
Net	3.82	± 0.6

Global Mean Adjustment Factor (Wm^{-2})*

	ERBE-like	FLASHFlux
LW	0.62	1.98
SW	1.42	3.44
Net	-3.46	-7.28

* Adjustment required to anchor the specific dataset to the EBAF baseline

Global Mean Differences and Adjustment Factors (New)

ERBE-like minus EBAF (Wm^{-2})

	Mean	Std. Dev.
LW	-0.62	± 0.1
SW	-1.42	± 0.4
Net	3.46	± 0.5

FLASHFlux minus ERBE-like (Wm^{-2})

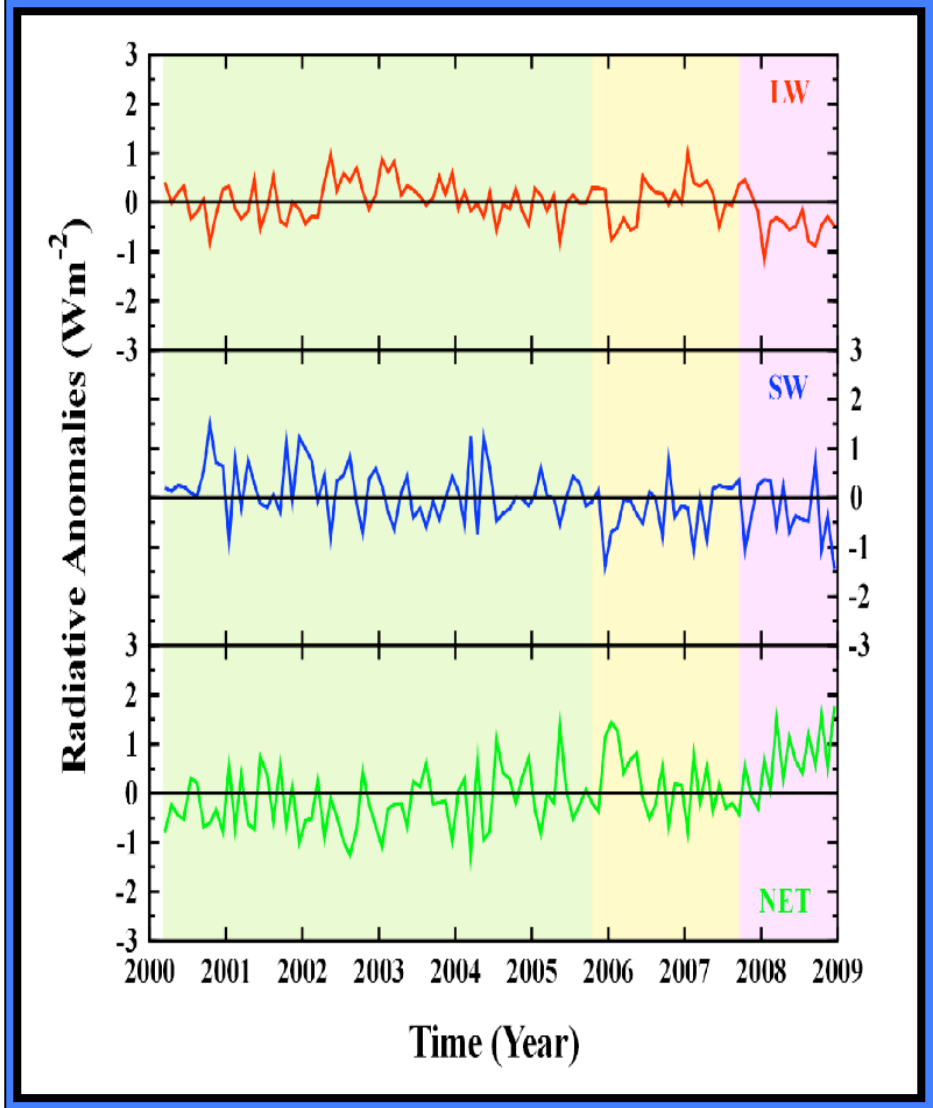
	Mean	Std. Dev.
LW	-1.36	± 0.1
SW	**-2.22**	± 0.5
Net	**3.73**	**± 0.4**

Global Mean Adjustment Factor (Wm^{-2})*

	ERBE-like	FLASHFlux
LW	0.62	1.98
SW	1.42	**3.64**
Net	-3.46	-7.19

* Adjustment required to anchor the specific dataset to the EBAF baseline

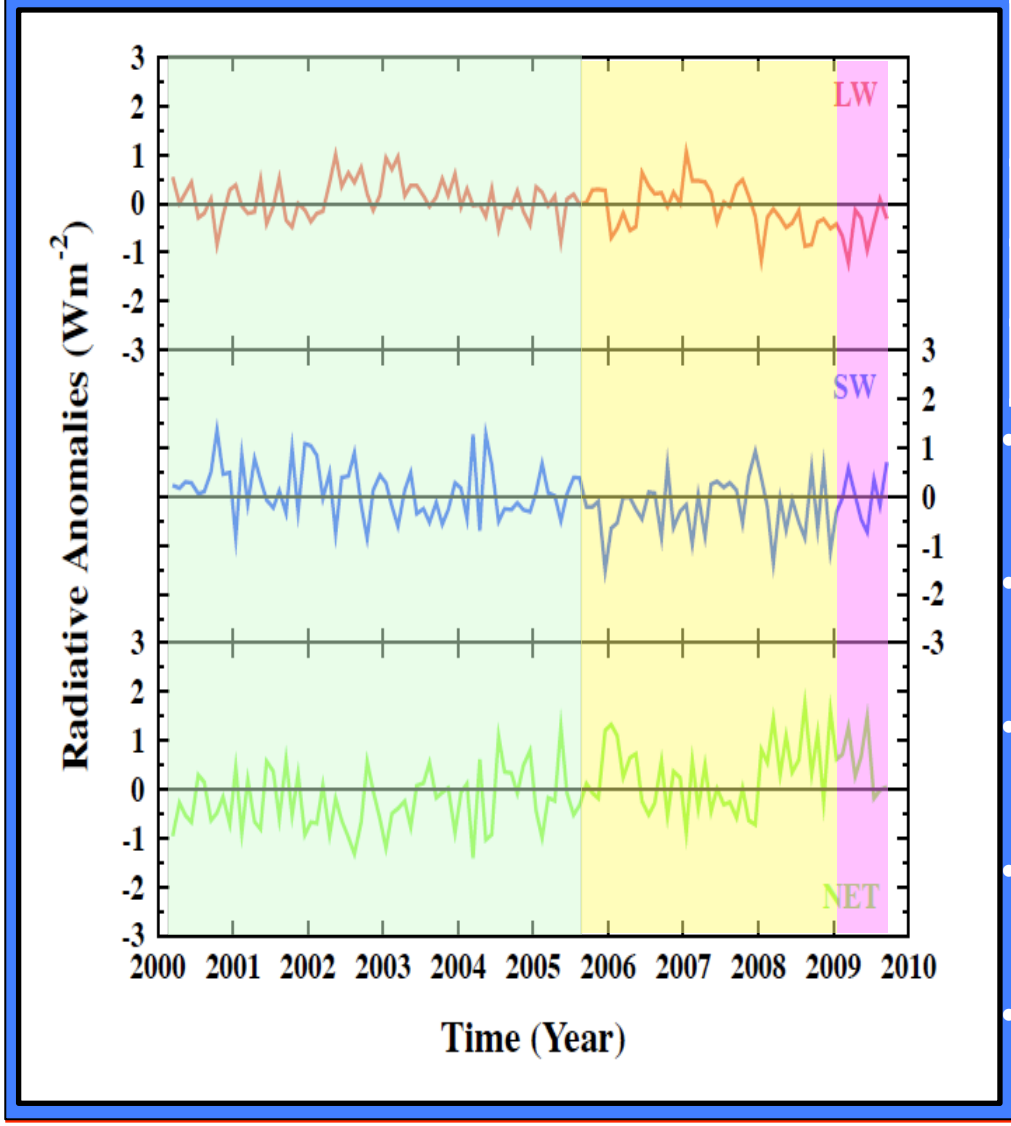
Deseasonalized Anomalies (Preliminary)



	2008 – 2007 change	2008 anomaly	Interannual variability (2-sigma)
LW	-0.74	-0.54	±0.56
SW	-0.14	-0.26	±0.41
Net	+0.89	+0.80	±0.82

- Large decrease in global mean outgoing longwave radiation in 2008
- Smaller decrease in global mean reflected shortwave in 2008
- Large increase in global mean net flux in 2008
- Majority of net flux increase (~84%) from decrease in longwave
- FLASHFlux calibration issue in 2008 or real climate change signal?

Deseasonalized Anomalies (Updated)



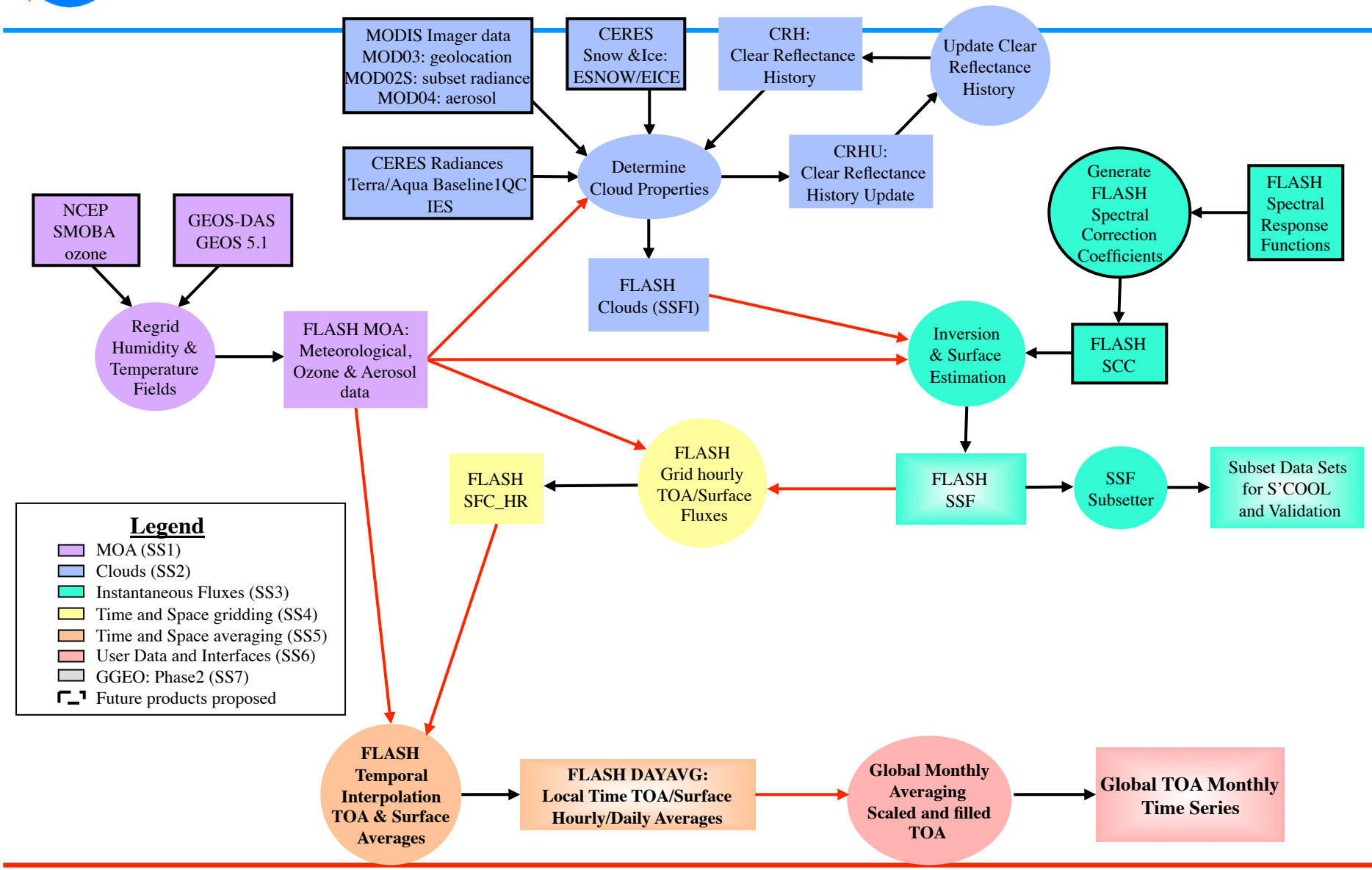
	2008 – 2007 change	2008 anomaly	Interannual variability (2-sigma)
LW	-0.74	-0.48	±0.56
SW	-0.33	-0.33	±0.39
Net	+1.07	+0.81	±0.82

- Large decrease in global mean outgoing longwave radiation in 2008 – same
- Decrease in global mean reflected shortwave in 2008 (+0.19 Wm^{-2})
- Large increase in global mean net flux in 2008 (slightly larger +0.18 Wm^{-2})
- Majority of net flux increase (~69%) from decrease in longwave
- FLASHFlux showing realistic variability

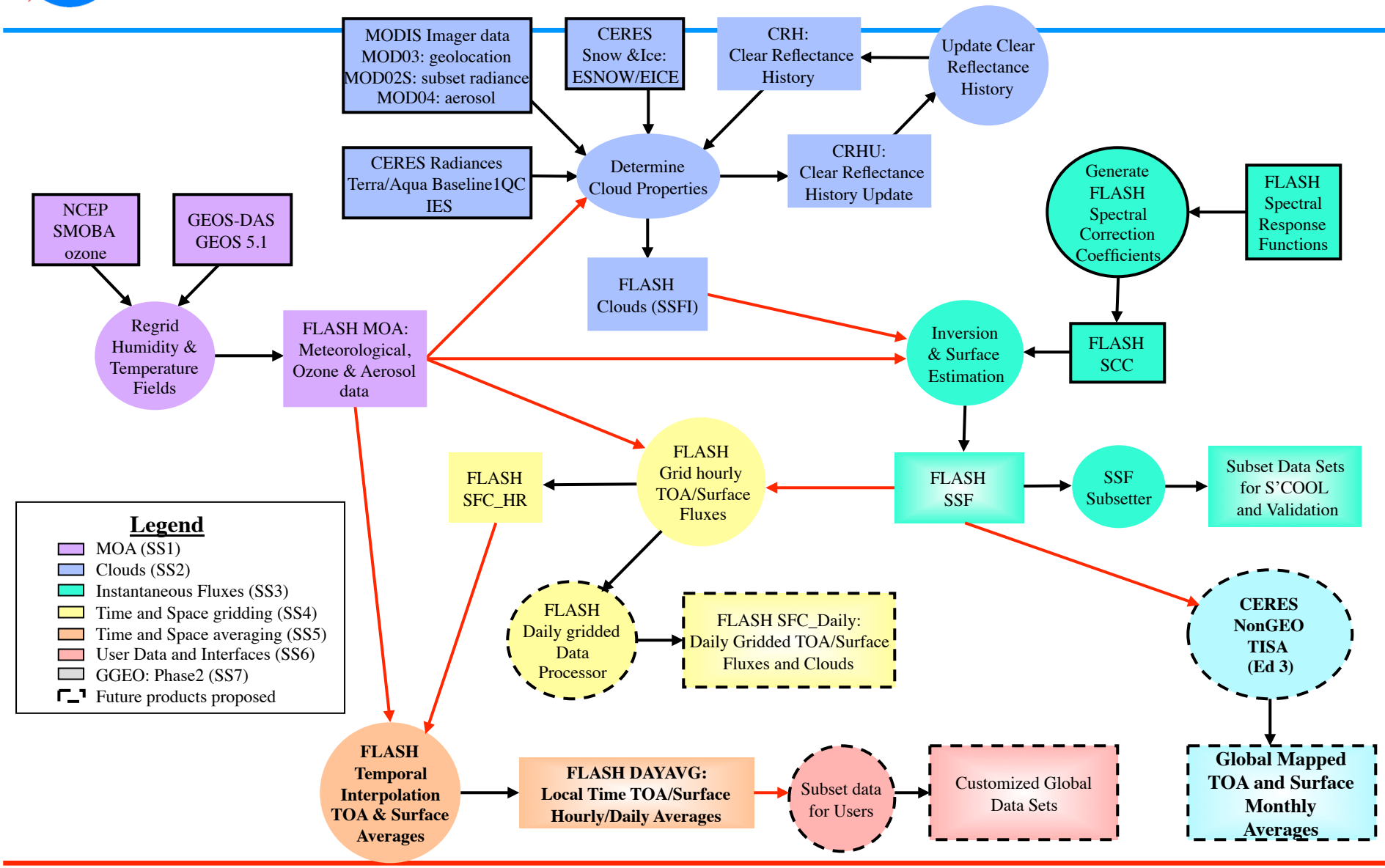
Future Upgrades and Challenges

- ***Transition of Operation Code to Cluster System at ASDC***
  - MOA tested more worked required
  - Need Clouds, Inversion, FLASH TISA
- ***Prepare for new operational reanalysis from GMAO***
  - Resolution now 0.25 lat x 0.3125 lon, new levels
- ***Deliver and test non-GEO version of CERES TISA to:***
  - Estimate all-sky/clear-sky TOA and Surface fluxes
  - Provide monthly averaged maps
- ***Develop new products and subsets***

Current FLASHFlux Data Flow



Future FLASHFlux Data Flow



Summary and Conclusions

- ***FLASHFlux Operational and …***
  - Producing global TOA/surface cloud products and radiative fluxes within 1 week after Terra/Aqua overpass
    - SSF products for both Terra and Aqua now used by CloudSat, CERES Science Team, S'COOL and soon CALIPSO
    - TISA products providing 1ºx1º global hourly/daily fluxes for Terra+Aqua data shown accurate for scientific analysis (e.g., TOA Global averages, Arctic Analysis CloudSat, NEWS) and agricultural use (e.g. Agriculture).
  - Has large potential for considerably more usage in both science (data analysis and assimilation) and applied sciences (energy)
  - Demonstrates potential as part of future systems like NPP and NPOESS
- ***FLASHFlux Is Working Towards …***
  - Transitioning production system to new cluster based system
  - Providing new operational monthly products and other products
  - Preparing for new operational GMAO analysis

FLASHFlux Web Sites:

http://flashflux.larc.nasa.gov

http://eosweb.larc.nasa.gov/PRODOCS/flashflux/table_flashflux.html

Extras

TOA Radiation Datasets

CERES Terra
EBAF Edition1A
3/2000 to 10/2005

→ *Most accurate using new CERES algorithms (updated in-orbit calibration, new CERES ADM, MODIS scene ID, best diurnal cycle using GEO data, ..) with global net radiation anchored to ocean heat storage value*

CERES Terra
ERBE-like ES4
Edition2_Rev1
1/2003 to 8/2007

→ *Not as accurate as EBAF, but highly stable, using old ERBE algorithms (updated in-orbit calibration, ERBE ADM, ERBE scene ID, ERBE constant meteorology, ..)*

FLASHFlux
Terra+Aqua
7/2006 to 12/2008

→ *May contain calibration drift; based on new CERES algorithms (new CERES ADM, MODIS scene ID, enhanced diurnal cycle with Terra + Aqua data, ..) with constant calibration coefficients from last known CERES values*

TOA Radiation Datasets

CERES Terra
EBAF Edition1A
3/2000 to 10/2005

→ *Most accurate using new CERES algorithms (updated in-orbit calibration, new CERES ADM, MODIS scene ID, best diurnal cycle using GEO data, ..) with global net radiation anchored to ocean heat storage value*

CERES Terra
ERBE-like ES4
Edition2_Rev1
1/2003 to 12/2008

→ *Not as accurate as EBAF, but highly stable, using old ERBE algorithms (updated in-orbit calibration, ERBE ADM, ERBE scene ID, ERBE constant meteorology, ..)*

FLASHFlux
Terra+Aqua
7/2006 to 9/2009

→ *May contain calibration drift; based on new CERES algorithms (new CERES ADM, MODIS scene ID, enhanced diurnal cycle with Terra + Aqua data, ..) with constant calibration coefficients from last known CERES values*

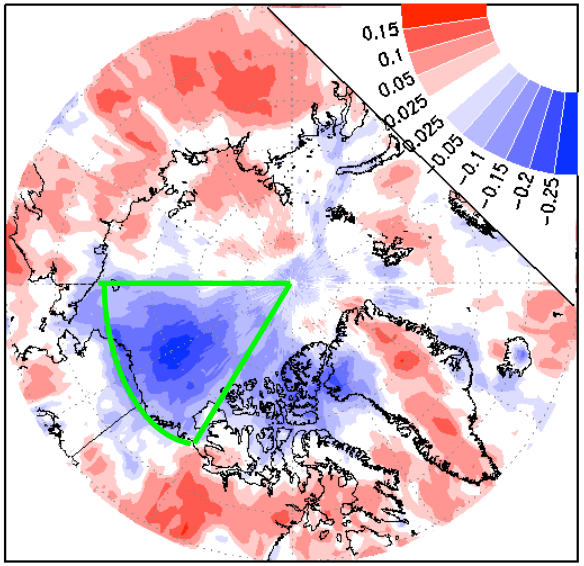
Future FLASHFlux Data Uses

- ***Global, Land and Ocean Assimilation***
  - GMAO GEOS => global validation of cloud radiative effects
  - GLDAS => 1x1 fluxes useful for input to coarse assimilation runs & analysis
  - Ocean Analysis => useful for input to ocean analysis project (WHOI)
- ***Energy Applications***
  - Independent daily data sets required for Building Monitoring and Targeting Program (NRCAN RETScreen)
  - Consistent global solar radiation for crop modeling and analysis of most season

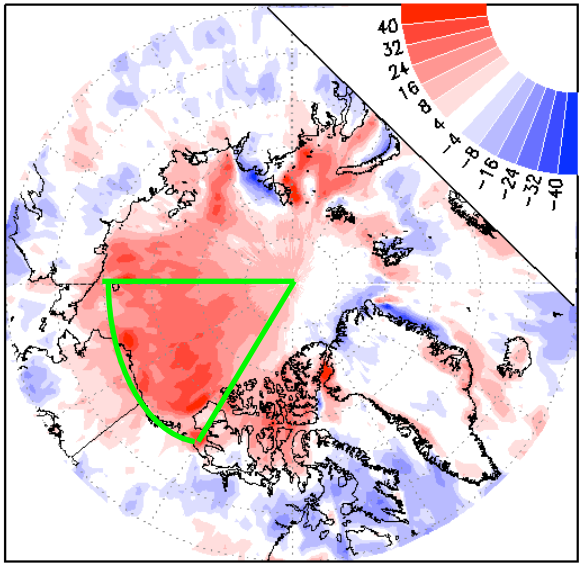
FLASHFlux Scientific Analysis

Mean of JJA 2007 - Mean JJA 2000-2004 (from CERES)

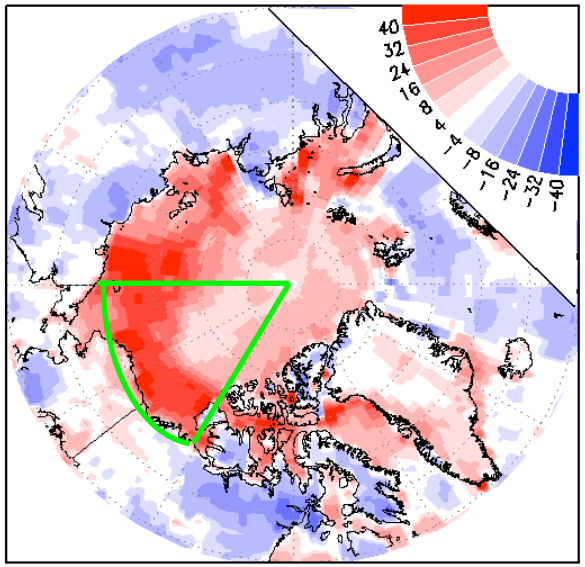
Cloud Fraction Anomaly



TOA Total Net Flux Anomaly (W m^{-2})



Surface Total Net Flux Anomaly (W m^{-2})



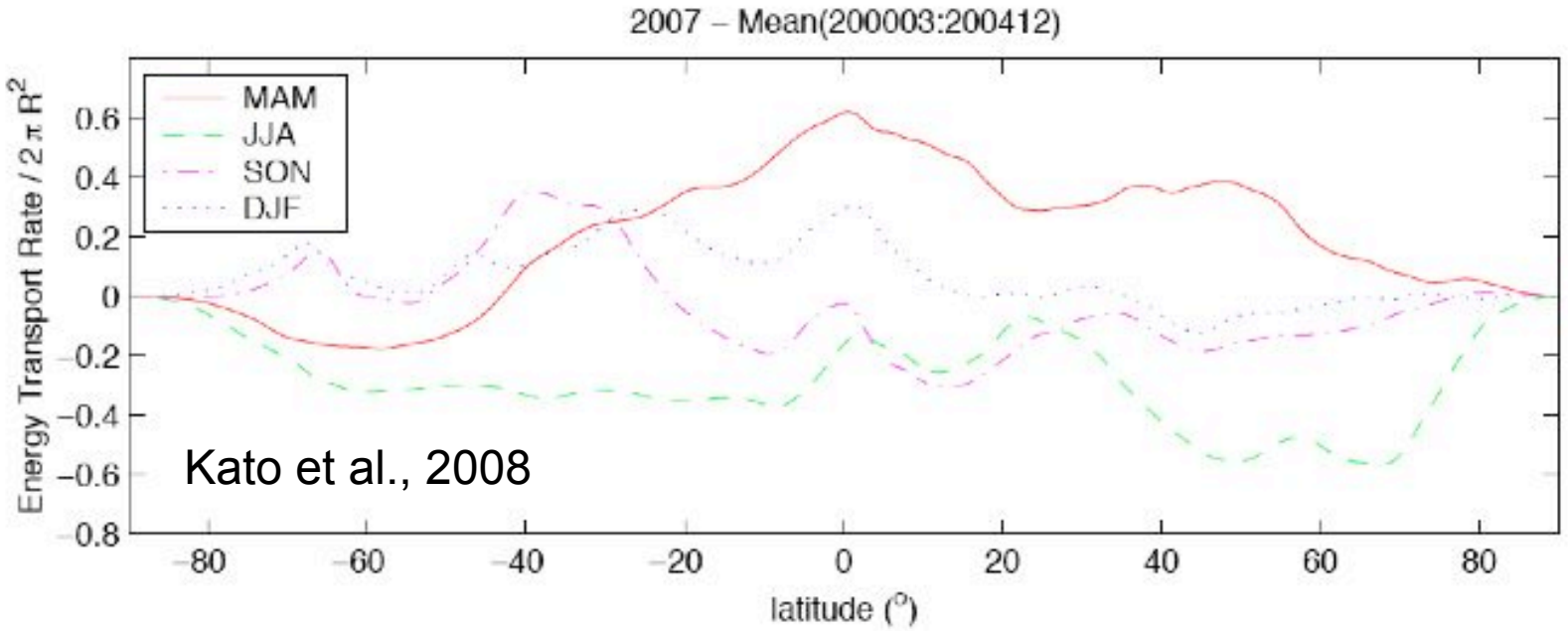
Western Arctic Sector Averages (120 W to 180 W; 70N to Pole)

-13.8% ***+24.2 W m^{-2}*** ***+21.4 W m^{-2}***

FLASHFlux Scientific Analysis

Meridional Energy transport

Anomalies of the rate of meridional energy transport

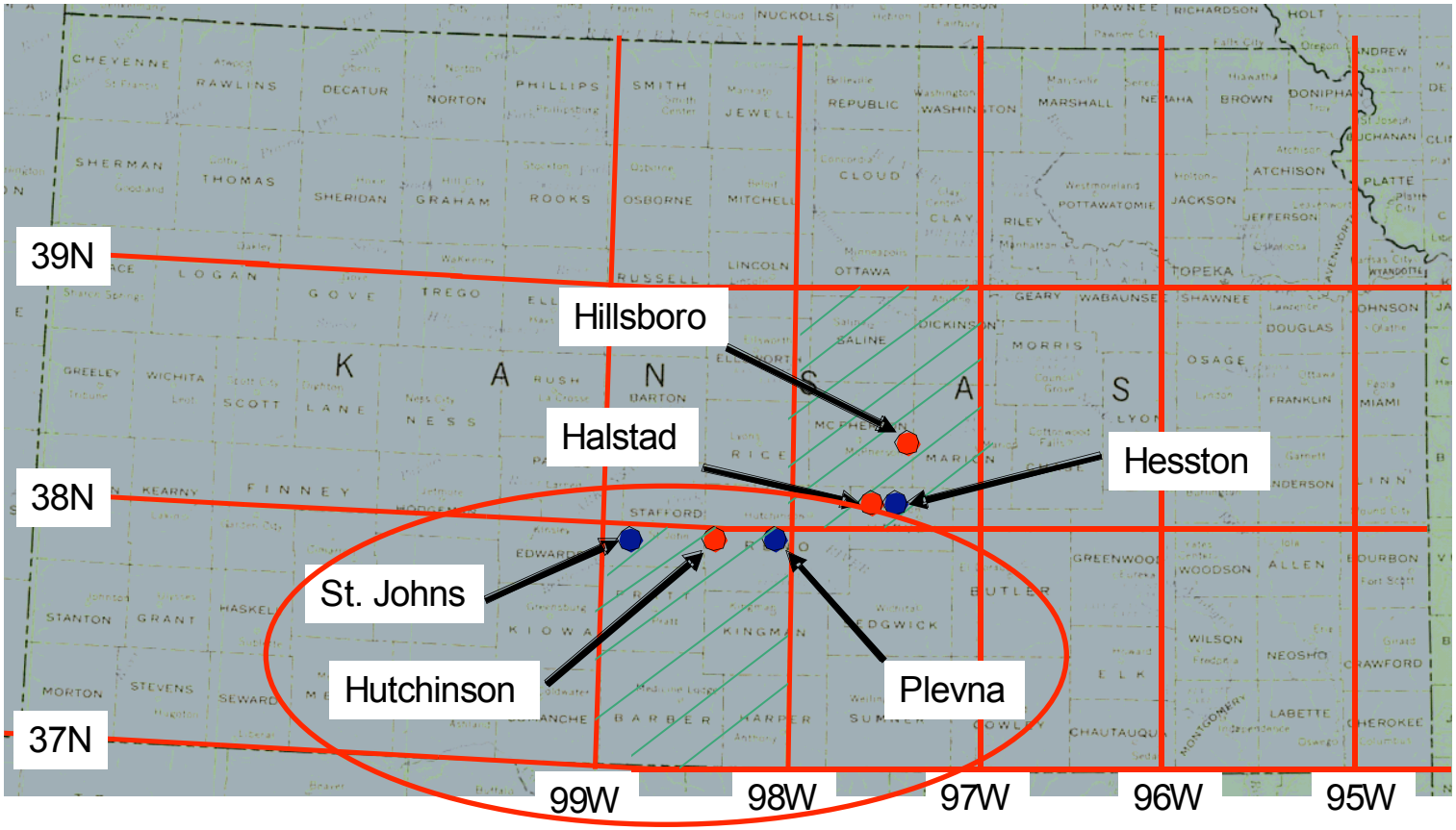


How much are these related to sea ice anomalies?

Is there any relations to a larger cloud cover in March - May 2007 ?

FLASHFlux: Find Errant Agricultural Sites for Improved Crop Modeling

- Atmospheric Radiation Measurement (ARM) Ground Site (DOE)
- High Plains Research Climate Center (HPRCC) Ground Site (Agricultural Site)

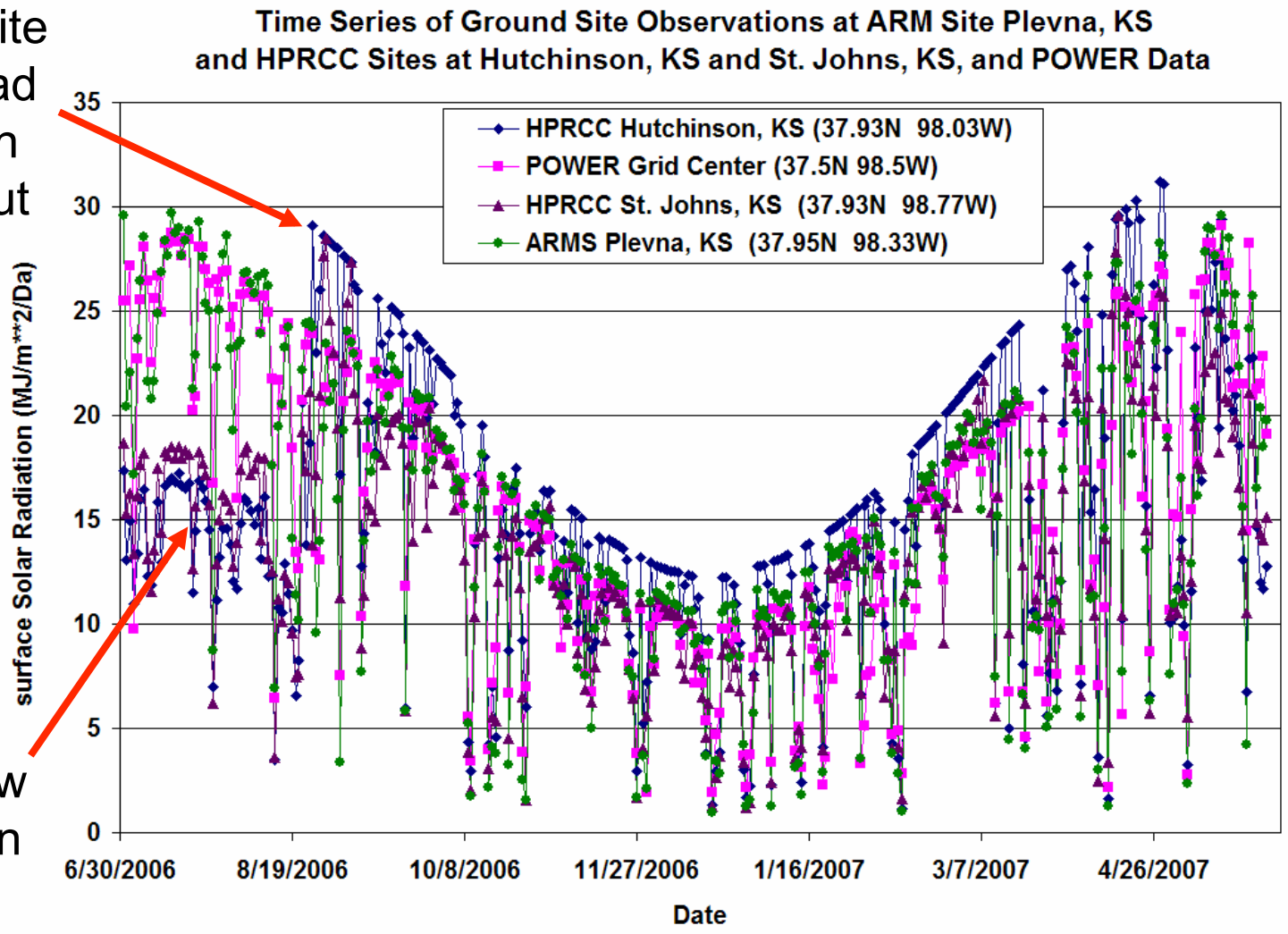


Note: agricultural sites used for crop yield projections

FLASHFlux: Find Errant Agricultural Sites for Improved Crop Modeling

One Ag site retains bad calibration throughout year

Both Ag sites show calibration error



FLASHFLUX Data Set Usage

- ***Scientific Near-Real Time Surface Flux Uses***
  - Scientific investigation of radiative anomalies due to climate extremes
    - Example 2007 Arctic Summer
  - Climate anomaly detection
  - Provide inputs for other NASA Missions (CLOUDSat, CERES) and NASA research project projects (NASA NEWS)
  - Provide inputs for land and ocean assimilation teams (GSFC GMAO-GEOS, LDAS, WHOI)
  - Provide inputs to seasonal prediction teams (GSFC GMAO NSIPP)
- ***Applied Science Potential Uses***
  - Provide datasets to energy (regional resource and load information)
  - Agricultural sector applications (crop yield projections)
    - Example: detection of faulty calibrations for COOP agricultural networks
- ***Education Uses***
  - NASA Earth Observatory availability
  - CERES S'COOL project

FLASHFlux: Applied Science Uses

- ***Energy Uses***
  - Determination and monitoring of solar energy resource and storage:
    - evaluate productivity/efficiency of buildings systems performance (with RETScreen (Monitoring and Targeting Program))
    - Resource availability relative to climatological resource
  - Use for inputs to models that predict near-term and/or potential long-term resource:
    - training of neural network maintenance systems (EPRI)
    - inputs for deterministic or statistical resource predictions
- ***Agricultural Uses***
  - Accumulated solar flux and meteorological resources related to crop maturity
    - net SW and LW fluxes related to soil moisture and evaporation
  - Detection of errant surface sites in agricultural networks (example follows)

FLASHFlux: Find Errant Agricultural Sites for Improved Crop Modeling

One Ag site shows good calibration

One Ag sites shows calibration error